Do baby-talk words reflect biomechanical constraints on speech production?

Do baby-talk words reflect biomechanical constraints on speech production?

Barbora Skarabela, Mitsuhiko Ota, Judit Fazekas and Lovisa Wihlborg

University of Edinburgh
barbora@ling.ed.ac.uk, mits@ling.ed.ac.uk, fffjudit@gmail.com, and lovisa@hjinello.se

ABSTRACT

Baby-talk words are conventionalized lexical items used in infant-directed speech. According to the Frame/Content theory, the structure of baby-talk words reflects biomechanical constraints on speech production associated with the origin of speech, a hypothesis that yields three predictions — compared to adult vocabulary, baby-talk words should exhibit (1) more canonical CV syllables, (2) more intrasyllabic CV co-occurrence patterns that minimize tongue movement, and (3) a stronger preference for intersyllabic CVC patterns with labial-vowel-coronal, rather than coronal-vowel-labial, sequences. We tested these predictions in a corpus of 351 baby-talk words (e.g., *choochoo*) matched with their corresponding adult alternatives (e.g., *train*) in 10 languages. Although the results support the prediction related to canonical CV syllables, they fail to confirm the two predictions related to intrasyllabic and intersyllabic segmental sequences. Baby-talk words do not appear to be any more compliant with the proposed biomechanical constraints than adult words, except in having more canonical CV syllables.

Keywords: baby-talk words, Frame/Content theory, articulatory constraints, CV structure

1. INTRODUCTION

A readily noticeable feature of infant-directed speech (IDS) is the use of baby-talk words [3, 4]. Baby-talk words are conventionalized register-specific lexical items such as *choochoo* ('train'), *bunny* ('rabbit'), and *doggy* ('dog'), which are used primarily with infants and small children in place of their adult-language equivalents. Such register-specific words exist across culturally and linguistically diverse speech communities, and exhibit strikingly similar structural characteristics, such as the preponderance of full and partial reduplication and paucity of consonant clusters [3, 4].

The source and origin of this substitutive vocabulary are a matter of controversy. One hypothesis suggests that baby-talk words descend from proto-words in the early stages of the evolution of speech, preserved in modern day parent-child interactions because of their phonetically simple structure [7]. Phonetic simplicity in this context has been interpreted specifically within the Frame/Content theory [5, 6]. According to this theory, three broadly defined design features related to articulatory movement are privileged in speech production. First, the rhythmic alternation between vocal tract occlusion and phonation that is associated with mandibular oscillation renders the CV syllable the most basic, or canonical, articulatory unit in human speech, particularly when the consonant involves total occlusion of the vocal tract (i.e., an oral or nasal stop). Second, biomechanical constraints on tongue movement favor three intrasyllabic CV co-occurrence patterns: coronal consonants followed by front vowels, labial consonants followed by central vowels, and dorsal consonants followed by back vowels. The first and third co-occurrence patterns (coronal-front and dorsal-back) involve minimal movement of the tongue due to similar points of articulation between the consonant and the vowel. The second pattern (labial-central) also respects lingual inertia as the tongue prefers to be in its resting position during non-lingual oral movements such as lip closure. The third design feature identified by the Frame/Content theory is a preference for labial consonant-vowel-coronal consonant (LC) sequences for word initiation. This is attributed to the ease of articulation involving a labial onset compared to a coronal or dorsal onset, the latter of which requires a tongue movement in addition to a single mandibular oscillation cycle.

Preference for the intra- and intersyllabic patterns mentioned above has been observed in adult words [6, 8], babbling [1, 8], and children's early word production [2, 8]. In particular, these patterns and canonical CV syllables predominate babbling and early word production, suggesting that immature speakers, due to their limited motor control, tend to produce phonetic forms that are more consistent with the biomechanical principles of the Frame/Content theory. If baby-talk words are motivated by similar articulatory mechanisms, we also expect their structure to exhibit these phonetic characteristics more clearly than adult words.

There is currently only some limited evidence in support of this general prediction. MacNeilage and Davis [7] examined a set of 80 CVCV baby-talk

words they extracted from a six-language corpus collected by Ferguson [3], and found above-chance observed-to-expected ratios for coronal-front, labial-central and dorsal-back CV co-occurrence patterns. However, to our knowledge, no analysis has been carried out to this date to examine whether baby-talk words exhibit a stronger tendency than adult words toward canonical CV syllables and the intra- and intersyllabic sequential patterns that are thought to be compliant with the articulatory constraints of early speech production.

The purpose of this study was to test these predictions in a set of baby-talk words and their semantically-matched adult words sampled from 10 languages. More specifically, we compared the baby-talk words with their adult word counterparts to test whether they have 1) a higher proportion of canonical CV syllables, 2) higher observed-to-expected ratios of coronal-front, labial-central and dorsal-back CV co-occurrences, and 3) a higher observed-to-expected ratio for labial-vowel-coronal intersyllabic sound sequences compared to the opposite coronal-vowel-labial sequences.

2. METHOD

We compiled a corpus of baby-talk words from 10 languages (Basque, Czech, English, Finnish, French, Greek, Hungarian, Japanese, Mandarin, and Swedish). We first identified 45 meanings in six semantic categories where baby-talk words are most commonly found according to previous literature [3]. These included kinship terms (e.g., mother), food items (e.g., milk), and body parts (e.g., stomach). This template was then distributed among native speaker informants in each language. For each meaning, the informants were asked to identify a conventionalized baby-talk form (e.g., *tummy*) and its corresponding adult lexical item (e.g., *stomach*). Some languages yielded more items than others. For example, the word 'rabbit' has a conventionalized baby-talk form in English (i.e., *bunny*) or Japanese (i.e., *usa-chan*) but not in Basque or Czech. As a result, the number of words per language varied from 22 in Hungarian to 51 in Japanese, with the average of 35 words per language. The resulting corpus consisted of 351 baby-talk words paired up with their corresponding adult alternatives.

A canonical CV syllable was defined as one that consists of a single onset consonant that was either an oral or nasal stop, followed by a vowel (monophthong or diphthong) but no coda consonants.

In previous studies examining the Frame/Content theoretic predictions for intra- and intersyllabic sequences, the analysis was often carried out only on CVCV words consisting of either oral or nasal stops (e.g., *today*, *bunny*) [2, 6, 7, 8]. However, this approach limits the sample to a small fraction of the words contained in the corpus, preventing us from checking the crosslinguistic generalizability of the results. For the purpose of the intrasyllabic CV patterns, we therefore examined all CV syllables, including those that appear in non-CVCV words (e.g., Finnish: *kakata*). Similarly, in analysing intersyllabic CVC patterns, we examined all words that begin with a CV.C sequence including words longer than two syllables. Furthermore, for the intrasyllabic and intersyllabic sequence analysis, we included all CV syllables with a supraglottal closure. For the languages in our dataset, this meant all oral stops, nasal stops, liquids, affricates, and fricatives, except /h/.

3. RESULTS

We first analysed the proportion of canonical CV syllables (defined as a single oral or nasal stop closure followed by a vowel) in adult words and baby-talk words. The results are given in Table 1. The comparison bears out the prediction of the Frame/Content theory; there is a higher incidence of canonical CV syllables in baby-talk words than in adult words, $t(9) = 3.42$, $p < 0.01$. This pattern is observed in 8 of the 10 languages examined.

Table 1: Percentages of CV syllables with oral or nasal stops.

Language	Adult words	Baby-talk words
Basque	45	40
Czech	32	52
English	16	77
Finnish	42	61
French	22	57
Greek	41	61
Hungarian	16	42
Japanese	46	42
Mandarin	31	38
Swedish	19	54
Mean	35	52

Next, we tested the prediction that baby-talk words have a stronger tendency than adult words toward the three biomechanically-preferred CV co-occurrence patterns. Table 2 shows the observed-to-expected ratios of all 9 place combinations in the CV syllables identified in baby-talk words pooled from all 10 languages. This analysis confirms MacNeilage and Davis's [7] observation that coronal-front, labial-central, and dorsal-back sequences have a

higher than chance (i.e., 1.0) ratio in baby-talk words.

Table 2: Observed-to-expected ratios of CV combinations in baby-talk words (pooled data).

	Vowel		
Consonant	Front	Central	Back
Coronal	1.11	0.96	0.91
Labial	0.88	1.04	0.99
Dorsal	0.97	0.97	1.09

In order to examine if this pattern is more prominent in baby-talk words than in adult words across languages, we calculated the observed-to-expected ratios for coronal-front, labial-central and dorsal-back CV co-occurrence patterns separately for adult words and baby-talk words in each language, and then averaged them across the 3 CV combination patterns. The results, presented in Table 3, show that these 3 CV patterns were generally preferred in *both* baby-talk words and adult words, and the average ratios did not differ between baby-talk words (1.12) and adult words (1.13), $t(9) = 0.095$, $p = 0.93$.

Table 3: Combined average observed-to-expected ratios of labial-central, coronal-front and dorsal-back CV co-occurrence patterns.

Language	Adult words	Baby-talk words
Basque	0.77	1.06
Czech	1.47	1.02
English	1.52	1.04
Finnish	1.11	0.89
French	1.40	0.46
Greek	0.90	0.92
Hungarian	1.09	1.64
Japanese	0.85	1.39
Mandarin	1.28	1.70
Swedish	0.96	1.08
Mean	1.13	1.12

Finally, we tested the prediction that intrasyllabic preference for labial-coronal (LC) sequences over coronal-labial (CL) sequence should be stronger in baby-talk words than in adult words. As with the analysis for CV combinations, we first examined the pooled data for all baby-talk words and calculated the observed-to-expected ratios of the 9 place combinations between the first and second consonants in intersyllabic CVC sequences (Table 4). The results make it abundantly clear that the most preferred intrasyllabic pattern is not LC, but one in which the first and second consonants share the same place of articulation. This reflects the well-known preponderance of reduplication in baby-talk words (e.g., *poo-poo*). However, the results do confirm the expected asymmetry between LC (0.41) and CL (0.25).

Table 4: Observed-to-expected ratios of consonant-consonant combinations in intersyllabic CVC sequences in baby-talk words (pooled data).

	Consonant 2		
Consonant 1	Cor	Lab	Dor
Coronal	1.76	0.25	0.28
Labial	0.41	1.94	0.85
Dorsal	0.75	0.32	3.05

In order to examine if this pattern is more prominent in baby-talk words than in adult words across languages, we calculated an LC preference score separately for adult words and baby-talk words for each language by subtracting the observed-to-expected ratio for CL sequences from that for LC sequence. A positive value in this score indicates a preference for LC over CL, and a negative value signals a preference for CL over LC.

The results are summarized in Table 5. The mean values indicate a slight overall preference for LC among baby-talk words and a slight preference for CL among adult words. This difference is primarily due to the extremely negative value of Hungarian adult words (excluding Hungarian raises the adult word mean to 0.31). Yet, even if we include the Hungarian data in the analysis, the baby-talk words and adult words do not differ statistically, $t(9) = 0.73$, $p = 0.48$.

Table 5: Difference in observed/expected ratios for labial-coronal (LC) sequence vs. coronal-labial (CL) sequence (LC minus CL).

Language	Adult words	Babytalk words
Basque	1.58	0.37
Czech	0.21	0.32
English	0.83	0.21
Finnish	0.00	-0.01
French	-0.14	0.11
Greek	-0.09	0.56
Hungarian	-3.89	0.00
Japanese	-0.13	-0.03
Mandarin	1.00	0.36
Swedish	-0.51	0.21
Mean	-0.11	0.21

4. DISCUSSION AND CONCLUSIONS

The aim of this study was to assess the hypothesis that baby-talk words are phonetically simpler than

their semantic counterparts in the adult lexicon in the sense that they show stronger conformity to the biomechanical constraints proposed in the Frame/Content theory. The results show that baby-talk words do indeed have a higher proportion of canonical CV syllables than their adult word alternatives. The study also replicates an earlier finding that the three biomechanically-privileged CV patterns have a higher-than-expected incidence in baby-talk words [7]. However, our results do not show that this tendency is stronger in baby-talk words than in adult words. Similarly, although LC sequences were overall more frequent than CL sequences in baby-talk words, the preference (measured as the observed/expected ratio difference between LCs and CLs) does not differ systematically between baby-talk words and adult words.

In other words, while our analysis shows that baby-talk words exhibit all the biomechanically-motivated phonetic tendencies predicted by the Frame/Content theory, it does not support the prediction that baby-talk words are more compliant with these constraints than adult words, with the exception that they have more canonical CV syllables. If baby-talk words reflect accommodation for the articulatory limitations of infants and young children toward phonetically simpler words, the accommodation seems to be confined to the CV syllable structure rather than any gesturally simpler sequential organization of segments.

As mentioned above, a methodological caveat to this conclusion is that our analysis of the intra- and intersyllabic patterns was not restricted to CV syllables with oral or nasal stops within CVCV words, but also included CV syllables with other closure types, occurring in words other than CVCVs. However, our analysis with the pooled data (summarized in Table 2) replicates MacNeilage and Davis's [7] similar analysis of baby-talk words with a more restricted data in that it demonstrates higher-than-chance observed-to-expected ratios for just the three predicted intrasyllabic CV patterns. We have reasons to believe, therefore, that the general outcomes are not largely affected by the expansion of scope in the data analysis.

The literature on early language development frequently highlights the phonetic commonalities between baby-talk words, babbling and children's early word production [4, 10]. However, our results indicate that conventionalized baby-talk words differ from early speech production. While babbling and early words show sequential organization of segments that is noticeably different from adult words, this is not the case for baby-talk words. This difference is likely to be related to the fact that babbling and early words are speech produced by infants and young children whereas baby-talk words are conventionalized lexical items that are part of the adult speaker's lexicon, though reserved primarily for infant-directed speech. As such, the biomechanical limitations of the young speaker do not dictate the structure of baby-talk words directly, but only through the filter of the adult interlocutor, who may be more sensitive in perceiving certain aspects of their offspring's speech capacity than others (e.g., whether they can produce onset clusters vs. whether they can produce coronal-back sequences). This interpretation is consistent with recent findings on the close connection between adults' perception of infant/child speech and the phonological characteristics of baby-talk words [9]. Thus, the effects of biomechanical constraints on baby-talk words, if any, appear to be mediated by caregivers' perception of infants' speech and speech capacities.

5. REFERENCES

[1] Davis, B. L., MacNeilage, P. F. 1995. The articulatory basis of babbling. *J. Speech, Language, and Hearing Research* 38, 1199–1211.

[2] Davis, B. L., MacNeilage, P. F., Matyear, C. L. 2002. Acquisition of serial complexity in speech production: A comparison of phonetic and phonological approaches to first word production. *Phonetica* 59, 75–107.

[3] Ferguson, C. A. 1964. Baby talk in six languages. *American Anthropologist* 66, 103–114.

[4] Ferguson, C. A. 1977. Baby talk as a simplified register. In: Snow, C. E., Ferguson, C. A. (eds), *Talking to Children*. Cambridge: Cambridge University Press, 209-235.

[5] MacNeilage, P. F. 1998. The frame/content theory of evolution of speech production. *Behavioral and Brain Sciences* 21, 499–511.

[6] MacNeilage, P. F., Davis, B. L. 2000. On the origin of internal structure of word forms. *Science* 288, 527–531.

[7] MacNeilage, P. F., Davis, B. L. 2004. Baby talk and the emergence of first words. *Behavioral and Brain Sciences* 27, 517–518.

[8] MacNeilage, P. F., Davis, B. L., Kinney, A., Matyear, C. L. 2000. The motor core of speech: A comparison of serial organization patterns in infants and languages. *Child Development* 71, 153–163.

[9] Nakai, S., Kunnari, S. 2014. On the perceived quantity of young children's speech segments. In: Celeta, C., Costamagna, L. (eds), *Consonant Gemination in First and Second Language Acquisition.* Pacini Editore, 119–144.

[10] Turpin, M., Demuth, K., Campbell, A. N. 2014. Phonological aspects of Arandic baby talk. In: Pensalfini, R., Turpin, M., Guillemin, D. (eds), *Language Description Informed by Theory*. Amsterdam: John Benjamins, 49-79.